```
Potato type L                -50:----------MATANGAH-LFNHYS-SNS-RFIHFTSR-NTSSKLFLT -17
Potato type L2               -81:----------MA--TFAVSGLNSISSISSFNNNFRSKNSNIL-LSRRRILLFS -42
Sweet potato type L          -43:----------M-----SR-LSGITP-RA--RDDRSQFQ-NPRLEIAVP -16
Fava bean type L             -64:MASMT-MRFHPNSTAVTESVPRRGSVYGFI-GYRSSS-LFV--RTNVIKY--RSVKRNLE -12
Arabidopsis thaliana type L    1:---MDTMRISGVSTGAEVLIQCN-SLSSLV-SRRCD---DGKWRTRMFPARNRDLRPSPT 52
Spinach                        1:---MATLPLSSTTPSTGRTENCFSSYYSSSISRVMEFGLKNGCNSK--LLFSSVNYKPMI 55
Rice type L                    1:------------------------------------------------------------ 1
Rice type L2                   1:----------MATASAPLQLATASRPLPVG-VGCGGGGGGGLHVGGAR 37
Corn type L                    1:----------GDDHLAAAAARHRLPPARLLLRRW-RGSPPRAVPE--VGSRR 39
Potato type H                  1:------------------------------------------------------------ 1
Fava bean type H               1:------------------------------------------------------------ 1
Arabidopsis thaliana type H    1:------------------------------------------------------------ 1
Rice type H                    1:------------------------------------------------------------ 1
Wheat                          1:------------------------------------------------------------ 1
Citrus type H                  1:------------------------------------------------------------ 1
E.coli MalQ                    1:------------------------------------------------------------ 1

Potato type L                -16:K-TSHFR-RP-KRCFHVNNTLSEK---IHHPITEQGGESDLSSF-APDA-ASIT-SSIKY 35
Potato type L2               -41:FRRRRRSFSVSSVASDQKQKTKDSSSDEGFT--LDVFQ-----PDSTSVLS----S-IKY  7
Sweet potato type L          -15:DRTAGLQ-RT-KRTLLVKCVLDETKQTIQHVVTEKNEGTLLDA-----A-S-IA-SSIKY 35
Fava bean type L             -11:FRRRSAF-S-VKCGSGNEAKQKVK-DQEVQQEAK--TSPS-SFA--PDT-TSIV-SSIKY 39
Arabidopsis thaliana type L   53:R--R-SF-LSVKSISSEP-KAKVT-DAVLDSEQEVFISSMNPFA--PDA-ASVA-SSIKY 102
Spinach                       56:MRGSRRCIVIRNVFSESKPKSEEPIIEQETPSILNPLSN--LSPDSASRQS----S-IKY 108
Rice type L                    1:----------RS--VAS-DRGVQGSVSP-EEEISSVLN-SIDS-STIA-SNIKH 37
Rice type L2                  38:-GGGAAPARR--RLAVRS--VAS-DRGVQGSVSP-EEEISSVLN-SIDS-STIA-SNIKH 87
Corn type L                   40:-VGVGVEGRLQRRVSARS--VAS-DRDVQGPVSP-AEGLPNVLN-SIGS-SAIA-SNIKH 91
Potato type H                  1:----------MEGGAKSND-VSAA-P-IAQPLSEDPTD-IASN-IKY 32
Fava bean type H               1:----------MGFKVE--TNGGDG--SLVSAKVPPLANPLAEKPDE-IASN-ISY 39
Arabidopsis thaliana type H    1:----------MANA----N--GKAATS-LPEKISAKANPEADDATE-IAGN-IVY 36
Rice type H                    1:----------MPESN--GAACGAAEKVKPAA--SPASEEPAA-IAGN-ISF 35
Wheat                          1:----------M-SA-ADKVKPAA--SPASEDPSA-IAGN-ISY 27
Citrus type H                  1:----------MADAKA--N--GKNEAAKLA-KIPAAANPLANEPSA-IASN-ISY 38
E.coli MalQ                    1:----------MSQPIFND 8
```

Fig. 1A

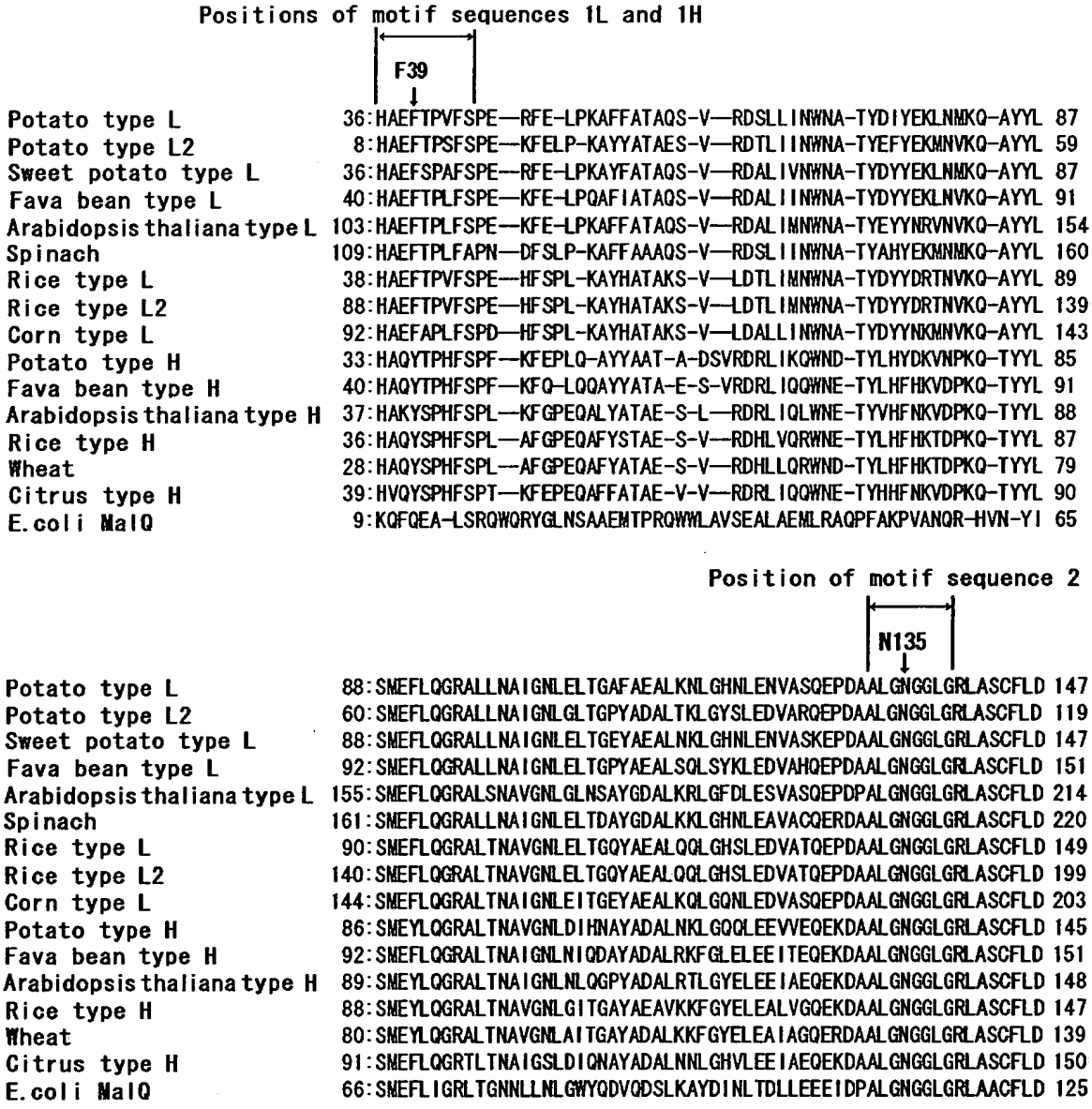
Positions of motif sequences 1L and 1H
F39
Potato type L 36:HAEFTPVFSPE—RFE-LPKAFFATAQS-V—RDSLLINWNA-TYDIYEKLNMKQ-AYYL 87
Potato type L2 8:HAEFTPSFSPE—KFELP-KAYYATAES-V—RDTLIINWNA-TYEFYEKMNVKQ-AYYL 59
Sweet potato type L 36:HAEFSPAFSPE—RFE-LPKAYFATAQS-V—RDALIVNWNA-TYDYYEKLNMKQ-AYYL 87
Fava bean type L 40:HAEFTPLFSPE—KFE-LPQAFIATAQS-V—RDALIINWNA-TYDYYEKLNVKQ-AYYL 91
Arabidopsis thaliana type L 103:HAEFTPLFSPE—KFE-LPKAFFATAQS-V—RDALIMNWNA-TYEYYNRVNVKQ-AYYL 154
Spinach 109:HAEFTPLFAPN—DFSLP-KAFFAAAQS-V—RDSLIINWNA-TYAHYEKMNMKQ-AYYL 160
Rice type L 38:HAEFTPVFSPE—HFSPL-KAYHATAKS-V—LDTLIMNWNA-TYDYYDRTNVKQ-AYYL 89
Rice type L2 88:HAEFTPVFSPE—HFSPL-KAYHATAKS-V—LDTLIMNWNA-TYDYYDRTNVKQ-AYYL 139
Corn type L 92:HAEFAPLFSPD—HFSPL-KAYHATAKS-V—LDALLINWNA-TYDYYNKMNVKQ-AYYL 143
Potato type H 33:HAQYTPHFSPF—KFEPLQ-AYYAAT-A-DSVRDRLIKQWND-TYLHYDKVNPKQ-TYYL 85
Fava bean type H 40:HAQYTPHFSPF—KFQ-LQQAYYATA-E-S-VRDRLIQQWNE-TYLHFHKVDPKQ-TYYL 91
Arabidopsis thaliana type H 37:HAKYSPHFSPL—KFGPEQALYATAE-S-L—RDRLIQLWNE-TYVHFNKVDPKQ-TYYL 88
Rice type H 36:HAQYSPHFSPL—AFGPEQAFYSTAE-S-V—RDHLVQRWNE-TYLHFHKTDPKQ-TYYL 87
Wheat 28:HAQYSPHFSPL—AFGPEQAFYATAE-S-V—RDHLLQRWND-TYLHFHKTDPKQ-TYYL 79
Citrus type H 39:HVQYSPHFSPT—KFEPEQAFFATAE-V-V—RDRLIQQWNE-TYHHFNKVDPKQ-TYYL 90
E.coli MalQ 9:KQFQEA-LSRQWQRYGLNSAAEMTPRQWWLAVSEALAEMLRAQPFAKPVANQR-HVN-YI 65
Position of motif sequence 2
N135
Potato type L 88:SMEFLQGRALLNAIGNLELTGAFAEALKNLGHNLENVASQEPDAALGNGGLGRLASCFLD 147
Potato type L2 60:SMEFLQGRALLNAIGNLGLTGPYADALTKLGYSLEDVARQEPDAALGNGGLGRLASCFLD 119
Sweet potato type L 88:SMEFLQGRALLNAIGNLELTGEYAEALNKLGHNLENVASKEPDAALGNGGLGRLASCFLD 147
Fava bean type L 92:SMEFLQGRALLNAIGNLELTGPYAEALSQLSYKLEDVAHQEPDAALGNGGLGRLASCFLD 151
Arabidopsis thaliana type L 155:SMEFLQGRALSNAVGNLGLNSAYGDALKRLGFDLESVASQEPDPALGNGGLGRLASCFLD 214
Spinach 161:SMEFLQGRALLNAIGNLELTDAYGDALKKLGHNLEAVACQERDAALGNGGLGRLASCFLD 220
Rice type L 90:SMEFLQGRALTNAVGNLELTGQYAEALQQLGHSLEDVATQEPDAALGNGGLGRLASCFLD 149
Rice type L2 140:SMEFLQGRALTNAVGNLELTGQYAEALQQLGHSLEDVATQEPDAALGNGGLGRLASCFLD 199
Corn type L 144:SMEFLQGRALTNAIGNLEITGEYAEALKQLGQNLEDVASQEPDAALGNGGLGRLASCFLD 203
Potato type H 86:SMEYLQGRALTNAVGNLDIHNAYADALNKLGQQLEEVVEQEKDAALGNGGLGRLASCFLD 145
Fava bean type H 92:SMEFLQGRALTNAIGNLNIQDAYADALRKFGLELEEITEQEKDAALGNGGLGRLASCFLD 151
Arabidopsis thaliana type H 89:SMEYLQGRALTNAIGNLNLQGPYADALRTLGYELEEIAEQEKDAALGNGGLGRLASCFLD 148
Rice type H 88:SMEYLQGRALTNAVGNLGITGAYAEAVKKFGYELEALVGQEKDAALGNGGLGRLASCFLD 147
Wheat 80:SMEYLQGRALTNAVGNLAITGAYADALKKFGYELEAIAGQERDAALGNGGLGRLASCFLD 139
Citrus type H 91:SMEFLQGRTLTNAIGSLDIQNAYADALNNLGHVLEEIAEQEKDAALGNGGLGRLASCFLD 150
E.coli MalQ 66:SMEFLIGRLTGNNLLNLGWYQDVQDSLKAYDINLTDLLEEEIDPALGNGGLGRLAACFLD 125

Fig. 1B

Potato type L	148:SLATLNYPAWGYGLRYKYGLFKQRITKDGQEEVAEDWLEIGSPWEVVRN-DV-SYPIKFY	205
Potato type L2	120:SMATLNYPAWGYGLRYQYGLFKQLITKDGQEEVAENWLEMGNPWEIVRN-DI-SYPVKFY	177
Sweet potato type L	148:SLATLNYPAWGYGLRYKYGLFKQRITKDGQEEVAEDWLELGNPWEIIRM-DV-SYPVKFF	205
Fava bean type L	152:SLATLNYPAWGYGLRYKYGLFKQRITKDGQEEVAEDWLEMGNPWEIVRN-DV-SYPVRFY	209
Arabidopsis thaliana type L	215:SMATLNYPAWGYGLRYKYGLFKQRITKDGQEEAAEDWLELSNPWEIVRN-DV-SYPIKFY	272
Spinach	221:SLATLNYPAWGYGLRYKYGLFKQMITKDGQEEVAENWLEIANPWELVRN-DV-SYSIKFY	278
Rice type L	150:SLATLNYPAWGYGLRYKHGLFKQIITKDGQEEVAENWLEMGNPWEIVRT-DV-SYPVKFY	207
Rice type L2	200:SLATLNYPAWGYGLRYKHGLFKANHTKDGQEEVAENWLEMGNPWEIVRT-DV-SYPVKFY	257
Corn type L	204:SLATLNYPALGYGLRYEYGLFKQIITKDGQEEIAENWLEMGYPWEVVRN-DV-SYPVKFY	261
Potato type H	146:SMATLNLPAWGYGLRYRYGLFKQLITKAGQEEVPEDWLEKFSPWEIVRH-DV-VFPIRFF	203
Fava bean type H	152:SMATLNLPAWGYGLRYRYGLFKQIITKEGQEEVAEDWLEKFSPWEIVRH-DV-LYPIRFF	209
Arabidopsis thaliana type H	149:SMATLNLPAWGYGLRYRHGLFKQIITKKGQEEIPEDWLEKFSPWEIVRH-DV-VFPVRFF	206
Rice type H	148:SMATLNLPAWGYGLRYRYGLFKQCITKEGQEEIAEDWLEKFSPWEIVRH-DI-VYPIRFF	205
Wheat	140:SMATLNLPSWGYGLRYRYGLFKQRIAKEGQEEIAEDWLDKFSPWEIVRH-DV-VYPIRFF	197
Citrus type H	151:SMATLNLPAWGYGLRYRYGLFKQKITKQGQEEVAEDWLEKFSPWEVVRH-DV-VFPVRFF	208
E.coli MalQ	126:SMATVGQSATGYGLNYQYGLFRQSFVDGKQVEAPDDWHRSNYPWF--RHNEALDVQVGIG	183

Potato type L	206:GKVSTGSDGKRYWIGGEDIKAVAYDVPIPGYKTRTTISLRLWSTQVPSADFDLSAFNAGE	265
Potato type L2	178:GKVIEGADGRKEWAGGEDITAVAYDVPIPGYKTKTTINLRLWTTKLAAEAFDLYAFNNGD	237
Sweet potato type L	206:GKVITGSDGKKHWIGGEDILAVAYDVPIPGYKTRTTISLRLWSTKVPSEDFDLYSFNAGE	265
Fava bean type L	210:GKVVSGSDGKKHWVGGEDIKAVAHDVPIPGYKTRSTINLRLWSTKAASEEFDLNAFNSGR	269
Arabidopsis thaliana type L	273:GKVVFGSDGKKRWIGGEDIVAVAYDVPIPGYKTKTTINLRLWSTKAPSEDFDLSSYNSGK	332
Spinach	279:GKVVSGSDGRSHWTGGEDIRAVAYDVPIPGYQTKTTINLRLWCTTVSSEDFDLSAFNAGE	338
Rice type L	208:GKVVEGTDGRMHWIGGENIKVVAHDIPIPGYKTKTTNNLRLWSTTVPSQDFDLEAFNAGD	267
Rice type L2	258:GKVVEGTDGRMHWIGGENIKVVAHDIPIPGYKTKTTNNLRLWSTTVPSQDFDLEAFNAGD	317
Corn type L	262:GKVVEGTDGRKHWIGGENIKAVAHDVPIPGYKTRTTNNLRLWSTTVPAQDFDLAAFNSGD	321
Potato type H	204:GHVEVLPSGSRKWVGGEVLQALAYDVPIPGYRTKNTNSLRLWEAKASSEDFNLFLFNDGQ	263
Fava bean type H	210:GQVEVNPDGSRQWIGGEVIQALAYDVPIPGYQTKNTISLRLWEAKACADDFDLFLFNDGQ	269
Arabidopsis thaliana type H	207:GKVQVNPDGSRKWVDGDVVQALAYDVPIPGYGTKNTISLRLWEAKARAEDLDLFQFNEGE	266
Rice type H	206:GHVEILPDGSRKWVGGEVLNALAYDVPIPGYKTKNAISLRLWDAKASAEDFNLFQFNDGQ	265
Wheat	198:GHVEISPDGKRKWAGGEVLNALAYDVPIPGYKTKNAISLRLWDATATAEDFNLFQFNDGQ	257
Citrus type H	209:GSVMVNPNGTRKWVGGEVVQAVAYDIPIPGYKTKNTISLRLWDAKASAEDFNLFQFNDGQ	268
E.coli MalQ	184:GKVTK--DGR--WEPEFTITGQAWDLPVVGYRNGVAQPLRLWQATHAHP-FDLTKFNDGD	238

Fig. 1C

```
Potato type L                266:HTKACEAQANAEKICYILYPGDESEEGKILRLKQQYTLCSASLQDIISRFERRSGDRIK- 324
Potato type L2               238:HAKAYEAQKKAEKICYVLYPGDESLEGKTLRLKQQYTLCSASLQDIIARFEKRSGNAVN- 296
Sweet potato type L          266:HTKACEAQANAEKICYILYPGDESIEGKILRLKQQYTLCSASLQDIIARFERRSGEYVK- 324
Fava bean type L             270:HTEASEALANAEKICYILYPGDESIEGKTLRLKQQYTLCSASLQDIIARFERRSGASVN- 328
Arabidopsis thaliana type L  333:HTEAAEALFNAEKICFVLYPGDESTEGKALRLKQQYTLCSASLQDIVARFETRSGGNVN- 391
Spinach                      339:HAKANEARANAEKICSVLYPGDESMEGKILRLKQQYTLCSASLQDIISQFERRSGEHVN- 397
Rice type L                  268:HASAYEAHLNAEKICHVLYPGDESPEGKVLRLKQQYTLCSASLQDIIARFERRAGDSLS- 326
Rice type L2                 318:HASAYEAHLNAEK----------P---------HY------R-DIIARFERRAGDSLS- 349
Corn type L                  322:HTKAYEAHLNAKKICHILYPGDESLEGKVLRLKQQYTLCSASLQDIIARFESRAGESLN- 380
Potato type H                264:YDAAAQLHSRAQQICAVLYPGDATENGKLLRLKQQFFLCSASLQDIIARFKEREDGKGSH 323
Fava bean type H             270:LESASVLHSRAQQICSVLYPGDATEGGKLLRLKQQYFLCSASLQDIISRFKERRQG---- 325
Arabidopsis thaliana type H  267:YELAAQLHSRAQQICTVLYPGDATENGKLLRLKQQFFLCSASLQDIISRFHERSTTEGSR 326
Rice type H                  266:YESAAQLHARAQQICAVLYPGDATEEGKLLRLKQQYFLCSASLQDIFFRFKERKADRVSG 325
Wheat                        258:YESAAQLHSRAQQICAVLYPGDATEEGKLLRLKQQYFLCSASLQDIIFRFKERKADRVSG 317
Citrus type H                269:YESAAQLHSRAQQICAVLYPGDSTEEGKLLRLKQQFFLCSASLQDMILRFKERKS--GR- 325
E.coli MalQ                  239:FLRAEQQGINAEKLTKVLYPNDNHTAGKKLRLMQQYFQCACSVADILRRH--HLAG---R 293

Potato type L                325:-WEE---FPEKVAVQMNDTHPTLCIPELMRILIDLKGLNWNEAWNITQRTVAYTNHTVLP 380
Potato type L2               297:-WDQ---FPEKVAVQMNDTHPTLCIPELLRILMDVKGLSWKQAWEITQRTVAYTNHTVLP 352
Sweet potato type L          325:-WEE---FPEKVAVQMNDTHPTLCIPELIRILIDLKGLSWKEAWNITQRTVAYTNHTVLP 380
Fava bean type L             329:-WED---FPEKVAVQMNDTHPTLCIPELMRILIDIKGLSWKDAWNITQRTVAYTNHTVLP 384
Arabidopsis thaliana type L  392:-WEE---FPEKVAVQMNDTHPTLCIPELMRILMDLKGLSWEDAWKITQRTVAYTNHTVLP 447
Spinach                      398:-WEE---FPEKVAVQMNDTHPTLCIPELMRILIDVKGLAWKEAWNITQRTVAYTNHTVLP 453
Rice type L                  327:-WED---FPSKVAVQMNDTHPTLCIPELMRILIDVKGLSWNEAWSITERTVAYTNHTVLP 382
Rice type L2                 350:-WED---FPSKVAVQMNDTHPTLCIPELMRILIDVKGLSWNEAWSITERTVAYTNHTVLP 405
Corn type L                  381:-WED---FPSKVAVQMNDTHPTLCIPELMRILMDVKGLSWSEAWSITERTVAYTNHTVLP 436
Potato type H                324:Q--WS-EFPKKVAIQLNDTHPTLTIPELMRLLMDDEGLGWDESWNITTRTIAYTNHTVLP 380
Fava bean type H             326:PWNWS-EFPTKVAVQLNDTHPTLSIPELMRLLMDDEGLGWDEAWAVTSKTVAYTNHTVLP 384
Arabidopsis thaliana type H  327:KWS---EFPSKVAVQMNDTHPTLAIPELMRLLMDDNGLGWDEAWDVTSKTVAYTNHTVLP 383
Rice type H                  326:KWS---EFPAKVAVQLNDTHPTLAIPELMRLLMDVEGLGWDEAWDITNKTIAYTNHTVLP 382
Wheat                        318:KWS---EFPSKVAVQMNDTHPTLAIPELMRLLMDVEGLGWDEAWAVTNKTVAYTNHTVLP 374
Citrus type H                326:QWS---EFPSKVAVQLNDTHPTLAIPELMRLLMDEEGLGWDEAWDITTRTVAYTNHTVLP 382
E.coli MalQ                  294:ELHELADYEV---IQLNDTHPTIAIPELLRVLIDEHQMSWDDAWAITSKTFAYTNHTLMP 350
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Fig. 1D

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Potato type L                  381:EALEKWSYELMQKLLPRHVEIIEAIDEELVHEIVLKYGSMDLNKLEEKLTTMRILENFDL 440
Potato type L2                 353:EALEKWSFTLLGELLPRHVEIIAMIDEELLHTILAEYGTEDLDLLQEKLNQMRILDNVEI 412
Sweet potato type L            381:EALEKWSYELMEKLLPRHIEIIEMIDEQLINEIVSEYGTSDLDMLEKKLNDMRILENFDI 440
Fava bean type L               385:EALEKWSMDLMEKLLPRHVEIIEMIDEELIRTIIAEYGTADSDLLDKKLKEMRILENVEL 444
Arabidopsis thaliana type L    448:EALEKWSLELMEKLLPRHVEIIEKIDEELVRTIVSEYGTADPDLLEEKLKAMRILENVEL 507
Spinach                        454:EALEKWSFELMQSLLPRHVEIIEKIDEELVDTIVSEYGTDDPKLLMGKLNELRILENFHL 513
Rice type L                    383:EALEKWSLDIMQKLLPRHVEIIEKIDGELMNIIISKYGTEDTSLLKKKIKEMRILDNIDL 442
Rice type L2                   406:EALEKWSLDIMQKLLPRHVEIIEKIDGELMNIIISKYGTEDTSLLKKKIKEMRILDNIDL 465
Corn type L                    437:EALEKWSLDIMQKLLPRHVEIIETIDEELINNIVSKYGTTDTELLKKKLKEMRILDNVDL 496
Potato type H                  381:EALEKWSQAVMWKLLPRHMEIIEEIDKRFVATIMS---ERP-DLENKMPS-MRIL------ 430
Fava bean type H               385:EALEKWSQPVMWKLLPRHMEIIEEIDRRFVALISK---TRL-DLEDEVSN-MRIL------ 434
Arabidopsis thaliana type H    384:EALEKWSQSLMWKLLPRHMEIIEEIDKRFVQTIRD---TRV-DLEDKISS-LSIL------ 433
Rice type H                    383:EALEKWSQIVMRKLLPRHMEIIEEIDKRFKEMVIS---TRK-EMEGKIDS-MRIL------ 432
Wheat                          375:EALEKWSQAVMKKLLPRHMEIIEEIDKRFREMVIS---TRK-DMEGKIES-MRVL------ 424
Citrus type H                  383:EALEKWSQAVMWKLLPRHMEIIEEIDKRFIAMVRS---TRS-DLESKIPS-MCIL------ 432
E.coli MalQ                    351:EALERWDVKLVKGLLPRHMQIINEINTR----------F---KT------L------ 382

Potato type L                  441:PSSVAELFIKPEISVDDDTETVEVHD-KVEASDKVVTNDEDDTGKKTSVKIEAAAE---- 495
Potato type L2                 413:PSSVLELLIKAEE-SAADV------E--KAADEEQEEEGKDD-SKDEETEA-VKAETTNEE 462
Sweet potato type L            441:PSSIANLFTKPK---ET---SIVDPSE-EVEVSGKVVTESVEVSDKVVTESEKDELEE---- 491
Fava bean type L               445:PAEFADILVKTKEATDISSEEVQIS---KEGGEEEE-TSKEGGEEEEEKEVGGGREEGDDG 502
Arabidopsis thaliana type L    508:PSAFADVIVKPVNKPVTAKDA-QNGV-KTEQEE-EKTA---GEEEED---------- 548
Spinach                        514:PSSVASII-KDKITCQVDE------D---KKI----------EIS-DEVD-GLVVVEESE--- 551
Rice type L                    443:PDSIAKLFVKPKEKKESPAKLKEKLLVK-SL-EPSVVVEEKTVSKV---EINEDSEEVEVD 498
Rice type L2                   466:PDSIAKLFVKPKEKKESPAKLKEKLLVK-SL-EPSVVVEEKTVSKV---EINEDSEEVEVD 521
Corn type L                    497:PASISQLFVKPKDKKESPAKSKQKLLVK-SL-ETIVEVEEKTELEEEAEVLSEIEEEKLE 554
Potato type H                  431:----------DH----------N---------- 433
Fava bean type H               435:----------DN----------N---------- 437
Arabidopsis thaliana type H    434:----------DN----------N---------- 436
Rice type H                    433:----------DN----------S---------- 435
Wheat                          425:----------DN----------N---------- 427
Citrus type H                  433:----------DN----------N---------- 435
E.coli MalQ                    383:--------V------EKTWPGDEKVWAK---LAV---------- 399
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Fig. 1E

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Potato type L                496:K----------DIDKKTPVS-----PEPAVIPPKKVRMANLCVVGGHAVNGVAEIHSE 538
Potato type L2               463:EETEVKKVEVEDSQAKIK----RIFG-PHPNKPQV--VHMANLCVVSGHAVNGVAEIHSE 515
Sweet potato type L          492:K----------DTELEKDED-----PVPAPIPPKMVRMANLCVVGGHAVNGVAEIHSD 534
Fava bean type L             503:KEDEVEKAIAEKDGTVKSSIGDKKKKLPEPVPVPPKLVRMANLCVVGGHAVNGVAEIHSE 562
Arabidopsis thaliana type L  549:---EV-------------------IPEPTVEPPKMVRMANLAVVGGHAVNGVAEIHSE 584
Spinach                      552:-EGDIEKQAVEEPVPK----------PAKL----VRMANLCIVGGHAVNGVAEIHSQ 593
Rice type L                  499:SEEVVEAENEDSEDELDPFV--KSD----PKL-PRV-VRMANLCVVGGHSVNGVAAIHSE 550
Rice type L2                 522:SEEVVEAENEDSEDELDPFV--KSD----PKL-PRV-VRMANLCVVGGHSVNGVAAIHSE 573
Corn type L                  555:SEEVEAEEAS-SEDELDPFV--KSD----PKL-PRV-VRMANLCVVGGHSVNGVAEIHSE 605
Potato type H                434:-------------------------ATK-PVV---HMANLCVVSSHTVNGVAQLHSD 461
Fava bean type H             438:-------------------------LQK-PVV---RMANLCVVSSHTVNGVAQLHSD 465
Arabidopsis thaliana type H  437:-------------------------PQK-PVV---RMANLCVVSSHTVNGVAQLHSD 464
Rice type H                  436:-------------------------NPQKPVV---RMANLCVVSAHTVNGVAELHSN 464
Wheat                        428:-------------------------P-EKPVV---RMANLCVVAGHTVNGVAELHSN 455
Citrus type H                436:-------------------------PKK-PVV---RMANLCVVSAHTVNGVAQLHSD 463
E.coli MalQ                  400:--------VHD------KQV----------------HMANLCVVGGFAVNGVAALHSD 427

Potato type L                559:IVKEEVFNDFYELWPEKFQNKTNGVTPRRWIRFCNPPLSAIITKWTGTEDWVLKTEKLAE 598
Potato type L2               516:IVKDEVFNEFYKLWPEKFQNKTNGVTPRRWLSFCNPELSEIITKWTGSDDWLVNTEKLAE 575
Sweet potato type L          535:IVKEDVFNDFYQLWPEKFQNKTNGVTPRRWIRFCNPALSNIITKWIGTEDWVLNTEKLAE 594
Fava bean type L             563:IVKDDVFNAFYKLWPEKFQNKTNGVTPRRWIRFCNPDLSKIITQWIGTEDWILNTEKLAE 621
Arabidopsis thaliana type L  585:IVKQDVFNDFVQLWPEKFQNKTNGVTPRRWIRFCNPYLSDIITNWIGTEDWVLNTEKVAE 644
Spinach                      594:IVKEQVFRDFFELWPEKFQNKTNGVTPRRWIRFCNPELSSILTKWIGSDDWVLNTEKLAE 653
Rice type L                  551:IVKEDVFNSFYEMWPAKFQNKTNGVTPRRWIRFCNPELSAIISKWIGSDDWVLNTDKLAE 610
Rice type L2                 574:IVKEDVFNSFYEMWPAKFQNKTNGVTPRRWIRFCNPELSAIISKWIGSDDWVLNTDKLAE 633
Corn type L                  606:IVKQDVFNSFYEMWPTKFQNKTNGVTPRRWIRFCNPALSALISKWIGSDDWVLNTDKLAE 665
Potato type H                462:ILKAELFADYVSVWPTKFQNKTNGITPRRWIRFCSPELSHIITKWLKTDQWVTNLELLAN 521
Fava bean type H             466:ILKSELFASYVSIWPTKFQNKTNGITPRRWINFCSPELSRIITKWLKTDKWVTNLDLLTG 525
Arabidopsis thaliana type H  465:ILKAELFADYVSIWPNKFQNKTNGITPRRWLRFCSPELSDIITKWLKTDKWITDLDLLTG 524
Rice type H                  465:ILKEELFADYLSIWPNKFQNKTNGITPRRWLRFCNPELSEIVTKWLKTDQWTSNLDLLTG 524
Wheat                        456:ILKQELFADYVSIWPNKFQNKTNGITPRRWLRFCNPELSEIVTKWLKTDQWTSNLDLLTG 515
Citrus type H                464:ILKADLFADYVSLWPNKLQNKTNGITPRRWLRFCNPELSKIITKWLKTDQWVTNLDLLVG 523
E.coli MalQ                  428:LVVKDLFPEYHQLWPNKFHNVTNGITPRRWIKQCNPALAALLDKSLQKE-WANDLDQLIN 486
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Fig. 1F

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Potato type L                599:LQKFADNEDLQNEWREAKRSNKIKVVSFLKEKTGYSVVPDAMFDIQVKRIHEYKRQLLNI 658
Potato type L2               576:LRKFADNEELQSEWRKAKGNNKMKIVSLIKEKTGYVVSPDAMFDVQIKRIHEYKRQLLNI 635
Sweet potato type L          595:LRKFADNEDLQIEWRAAKRSNKVKVASFLKERTGYSVSPNAMFDIQVKRIHEYKRQLLNI 654
Fava bean type L             622:LRKFADNEDLQTQWREAKRNNKVKVAAFLRERTGYSVSPDSMFDIQVKRIHEYKRQLLNI 681
Arabidopsis thaliana type L  645:LRKFADNEDLQSEWRAAKKKNKLKVVSLIKERTGYTVSPDAMFDIQIKRIHEYKRQLLNI 704
Spinach                      654:LRKFADNKDLHTEWMEAKRNNKQKVVSLIKERTGYTVSPDAMFDIQIKRIHEYKRQLMNI 713
Rice type L                  611:LKKFADDEDLQSEWRAAKKANKVKVVSLIREKTGYIVSPDAMFDVQVKRIHEYKRQLLNI 670
Rice type L2                 634:LKKFADDEDLQSEWRAAKKANKVKVVSLIREKTGYIVSPDAMFDVQVKRIHEYKRQLLNI 693
Corn type L                  666:LKKFADNEDLHSEWRAAKKANKMKVISLIREKTGYIVSPDAMFDVQVKRIHEYKRQLLNI 725
Potato type H                522:LREFADNSELHAEWESAKMANKQRLAQYILHVTGVSIDPNSLFDIQVKRIHEYKRQLLNI 581
Fava bean type H             526:LREFADNEDLQAEWLSAKRANKQRLAQYVLQVTGENIDPDSLFDIQVKRIHEYKRQLLNI 585
Arabidopsis thaliana type H  525:LRQFADNEELQSEWASAKTANKKRLAQYIERVTGVSIDPTSLFDIQVKRIHEYKRQLMNI 584
Rice type H                  525:LRKFADDEKLHAEWASAKLASKKRLAKHVLDVTGVTIDPNSLFDIQIKRIHEYKRQLLNI 584
Wheat                        516:LRKFADDEKLHAEWAAAKLASKKRLAKHVLDVTGVTIDPDSLFDIQIKRIHEYKRQLMNI 575
Citrus type H                524:LRQFADNTELQAEWESAKMASKKHLADYIWRVTGVTIDPNSLFDIQVKRIHEYKRQLLNI 583
E.coli MalQ                  487:LVKLADDAKFRDLYRVIKQANKVRLAEFVKVRTGIDINPQAIFDIQIKRLHEYKRQHLNL 546
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Positions of motif sequences 3L and 3H

T706

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Potato type L                659:FGIVYRYKKMKEMTAAERKTNFVPRVCIFGGKAFATYVQAKRIVKFITDVGATINHDPEI 718
Potato type L2               636:FGIVYRYKKMKEMSPEERKEKFVPRVCIFGGKAFATYVQAKRIVKFITDVGETVNHDPEI 695
Sweet potato type L          655:LGIVYRYKQMKEMSAREREAKFVPRVCIFGGKAFATYVQAKRIAKFITDVGATINHDPEI 714
Fava bean type L             682:FGIVYRYKKMKEMNAAERKENFVPRVCIFGGKAFATYVQAKRIVKFITDVGATVNHDPEI 741
Arabidopsis thaliana type L  705:LGIVYRYKKMKEMSASEREKAFVPRVCIFGGKAFATYVQAKRIVKFITDVASTINHDPEI 764
Spinach                      714:LGIVYRYKKMKEMSAAERKEKYVPRVCIFGGKAFATYVQAKRIVKFITDVGATINHDPEI 773
Rice type L                  671:LGIVYRYKKMKEMSAKDRINSFVPRVCIFGGKAFATYVQAKRIVKFITDVAATVNHDPEI 730
Rice type L2                 694:LGIVYRYKKMKEMSAKDRINSFVPRVCIFGGKAFATYVQAKRIVKFITDVAATVNHDPEI 753
Corn type L                  726:LGIVYRYKKMKEMSTEERAKSFVPRVCIFGGKAFATYIQAKRIVKFITDVAATVNHDSDI 785
Potato type H                582:LGVIYRYKKLKGMSPEERKNTT-PRTVMIGGKAFATYTNAKRIVKLVTDVGDVVNSDPDV 640
Fava bean type H             586:LGVIYRYKKLKEMSPEERKSTT-ARTVMIGGKAFATYTNAKRIVKLVDDVGSVVNSDPEV 644
Arabidopsis thaliana type H  585:LGVVYRFKKLKEMKPEERKKTV-PRTVMIGGKAFATYTNAKRIVKLVNDVGDVVNSDPEV 643
Rice type H                  585:LGAVYRYKKLKGMSAEERQKVT-PRTVMIGGKAFATYTNAKRIVKLVNDVGAVVNNDPDV 643
Wheat                        576:LGAVYRYKKLKEMSAADRQKVT-PRTVMVGGKAFATYTNAKRIVKLVNDVGAVVNNDADV 634
Citrus type H                584:LGAIYRYKKLKEMSPQERKKTT-PRTIMFGGKAFATYTNAKRIVKLVNDVGEVVNTDPEV 642
E.coli MalQ                  547:LHILALYKEIRENPQADRV----PRVFLFGAKAAPGYYLAKNIIFAINKVADVINNDPLV 602
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Fig. 1G

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Potato type L                    719:GDLLKVVFVPDYNVSVAELLIPASDLSEHISTAGMEASGTSNMKFAMNGCIQIGTLDGAN 778
Potato type L2                   696:GDLLKVVFVPDYNVSVAEVLIPGSELSQHISTAGMEASGTSNMKFSMNGCLLIGTLDGAN 755
Sweet potato type L              715:GDLLKVIFVPDYNVSAAELLIPASGLSQHISTAGMEASGQSNMKFAMNGCILIGTLDGAN 774
Fava bean type L                 742:GDLLKVIFVPDYNVSVAEMLIPASELSQHISTAGMEASGTSNMKFAMNGCLQIGTLDGAN 801
Arabidopsis thaliana type L      765:GDLLKVIFVPDYNVSVAELLIPASELSQHISTAGMEASGTSNMKFSMNGCVLIGTLDGAN 824
Spinach                          774:GDLLKVVFIPDYNVSVAELLIPASELSQHISTAGMEASGTSNMKFSMNGCILIGTLDGAN 833
Rice type L                      731:GDLLKVVFIPDYNVSVAEALIPASELSQHISTAGMEASGTSNMKFAMNGCILIGTLDGAN 790
Rice type L2                     754:GDLLKVVFIPDYNVSVAEALIPASELSQHISTAGMEASGTSNMKFAMNGCILIGTLDGAN 813
Corn type L                      786:GDLLKVVFVPDYNVSVAEALIPASELSQHISTAGMEASGTSNMKFAMNGCILIGTLDGAN 845
Potato type H                    641:NDYLKVVFVPNYNVSVAEMLIPGSELSQHISTAGMEASGTSNMKFALNGCLIIGTLDGAN 700
Fava bean type H                 645:NSYLKVVFVPNYNVSVAEVLIPGSELSQHISTAGMEASGTSNMKFALNRVLIIGTLDGAN 704
Arabidopsis thaliana type H      644:NEYLKVVFVPNYNVTVAEMLIPGSELSQHISTAGMEASGTSNMKFALNGCLIIGTLDGAN 703
Rice type H                      644:NKYLKVVFIPNYNVSVAEVLIPGSELSQHISTAGMEASGTSNMKFSLNGCVIIGTLDGAN 703
Wheat                            635:NKYLKVVFIPNYNVSVAEVLIPGSELSQHISTAGMEASGTSNMKFSLNGCVIIGTLDGAN 694
Citrus type H                    643:NSYLKVVFVPNYNVSVAELLIPGSELSQHISTAGMEASGTSNMKFSLNGCLIIGTLDGAN 702
E.coli MalQ                      603:GDKLKVVFLPDYCVSAAEKLIPAADISEQISTAGKEASGTGNMKLALNGALTVGTLDGAN 662

Potato type L                    779:VEIREEVGEENFFLFGAQAHEIAGLR-KERADGKFVPDERFEEVK--EFVRSGAFGSYN- 834
Potato type L2                   756:VEIREEVGEDNFFLFGAQAHEIAGLR-KERAEGKFVPDPRFEEVK--AFIRTGVFGTYN- 811
Sweet potato type L              775:VEIRQEVGEENFFLFGAEAHEIAGLR-KERAEGKFVPDERFEEVK--EFIKRGVFGSNT- 830
Fava bean type L                 802:VEIREEVGADNFFLFGAKAREIVGLR-KERARGKFVPDPRFEEVK--KFVRSGVFGSYN- 857
Arabidopsis thaliana type L      825:VEIREEVGEENFFLFGAKADQIVNLR-KERAEGKFVPDPTFEEVK--KFVGSGVFGSNS- 880
Spinach                          834:VEIREEVGEDNFFLFGARAHDIAGLR-KERAEGKYVPDPCFEEVK--EYVRSGVFGSNS- 889
Rice type L                      791:VEIREEVGEENFFLFGAEAHEIAGLR-KERAQGKFVPDPRFEEVK--RFVRSGVFGTYN- 846
Rice type L2                     814:VEIREEVGEENFFLFGAEAHEIAGLR-KERAQGKFVPDPRFEEVK--RFVRSGVFGTYN- 869
Corn type L                      846:VEIREEVGEENFFLFGAEAHEIAGLR-KERAEGKFVPDPRFEEVK--EFVRSGVFGTYS- 901
Potato type H                    701:VEIREEIGEDNFFLFGATADEVPQLR-KDRENGLFKPDPRFEEAK--QFIRSGAFGTYD- 756
Fava bean type H                 705:VEIREEIGEENFFLFGATADEVPRLR-KERENGLFKPDPRFEEAK--KFIRSGVFGSYD- 760
Arabidopsis thaliana type H      704:VEIREEVGEENFFLFGATADQVPRLR-KEREDGLFKPDPRFEEAK--QFVKSGVFGSYD- 759
Rice type H                      704:VEIREEVGQENFFLFGAKADQVAGLR-KDRENGLFKPDPRFEEAK--QLIRSGAFGTYD- 759
Wheat                            695:VEIREEVGQDNFFLFGAKADQVAGLR-KDRENGLFKPDPRFEEAK--QFIRSGAFGTYD- 750
Citrus type H                    703:VEIRQEIGEENFFLFGAGADQVPKLR-KEREDGLFKPDPRFEEAK--QFIRSGAFGSYD- 758
E.coli MalQ                      663:VEIAEKVGEENIFIFGHTVKQVKAILAKGYDPVKWRKKDKVLDAVLKELES-GKYSDGDK 721
```

Fig. 1H

Potato type L	835:--YDDLIGSLEGNEGFGRADYFLVGKDFPSYIECQEKVDEAYRDQKRWTTMSILNTAGSY	892
Potato type L2	812:--YEELMGSLEGNEGYGRADYFLVGKDFPDYIECQDKVDEAYRDQKKWTKMSILNTAGSF	869
Sweet potato type L	831:--YDELLGSLEGNEGFGRGDYFLVGKDFPSYIECQEKVDEAYRDQKIWTRMSILNTAGSY	888
Fava bean type L	858:--YDELIGSLEGNEGFGRADYFLVGQDFPSYLECQEEVDKAYRDQKKWTRMSILNTAGSS	915
Arabidopsis thaliana type L	881:--YDELIGSLEGNEGFGRADYFLVGKDFPSYIECQEKVDEAYRDQKRWTRMSIMNTAGSF	938
Spinach	890:--YDELLGSLEGNEGFGRADYFLVGKDFPSYVECQEQVDQAYRDQQKWTRMSILNTAGSF	947
Rice type L	847:--YDDLMGSLEGNEGYGRADYFLVGKDFPSYIECQEKVDKAYRDQKLWTRMSILNTASSS	904
Rice type L2	870:--YDDLMGSLEGNEGYGRADYFLVGKDFPSYIECQEKVDKAYRDQKLWTRMSILNTASSS	927
Corn type L	902:--YDELMGSLEGNEGYGRADYFLVGKDFPSYIECQEKVDEAYRDQKLWTRMSILNTAGSS	959
Potato type H	757:--YNPLLESLEGNSGYGRGDYFLVGHDFPSYMDAQARVDEAYKDRKRWIKMSILSTSGSG	814
Fava bean type H	761:--YNPLLDSLEGNSGYGRGDYFLVGYDFPSYMDAQEKVDEAYRDKKRWLKMSILSTAGSG	818
Arabidopsis thaliana type H	760:--YGPLLDSLEGNTGFGRGDYFLVGYDFPSYMDAQAKVDEAYKDRKGWLKMSILSTAGSG	817
Rice type H	760:--YAPLLDSLEGNSGFGRGDYFLVGYDFPSYIDAQAQVDEAYKDKKKWIKMSILNTAGSG	817
Wheat	751:--YTPLLDSLEGNTGFGRGDYFLVGYDFPSYIDAQARVDEAYKDKKKWVKMSILNTAGSG	808
Citrus type H	759:--YNPLLDSLEGNTGYGRGDYFLVGYDFPSYLEAQDRVDQAYKDRKKWLKMSILSTAGSG	816
E.coli MalQ	722:HAFDQWLHSIGKQGG-DP--YLVWA-DFAAYVEAQKQVDVLYRDQEAWTRAAILNTARCG	777

Potato type L	893:KFSSDRTIHEYAKDIW--NIEAVEIA	916
Potato type L2	870:KFSSDRTIHQYARDIW--RIEPVELP	893
Sweet potato type L	889:KFSSDRTIHEYAKDIW--NIQPVVFP	912
Fava bean type L	916:KFSSDRTIHEYAREIW--NIEPVKLE	939
Arabidopsis thaliana type L	939:KFSSDRTIHEYAKDIW--NIKQVELP	962
Spinach	948:KFSSDRTIHQYAKDIW--NIHPVNLP	971
Rice type L	905:KFNSDRTIHEYAKDIW--DIKPVILP	928
Rice type L2	928:KFNSDRTIHEYAKDIW--DIKPVILP	951
Corn type L	960:KFSSDRTIHEYAKDIW--DISPAILP	983
Potato type H	815:KFSSDRTISQYAKEIW--NIAECRVP	838
Fava bean type H	819:KFSSDRTIAQYAKEIW--NIEECRVP	842
Arabidopsis thaliana type H	818:KFSSDRTIAQYAKEIW--NIEACPVP	841
Rice type H	818:KFSSDRTIAQYAKEIW--GITASPVS	841
Wheat	809:KFSSDRTIDQYAKEIW--GISACPVP	832
Citrus type H	817:KFSSDRTIAQYAKEIW--NITECRTS	840
E.coli MalQ	778:MFSSDRSIRDYQARIWQAKR------	797

Fig. 1l

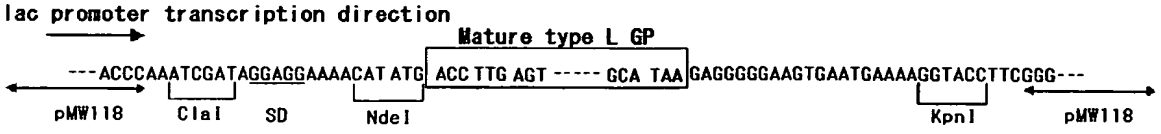


Fig. 2

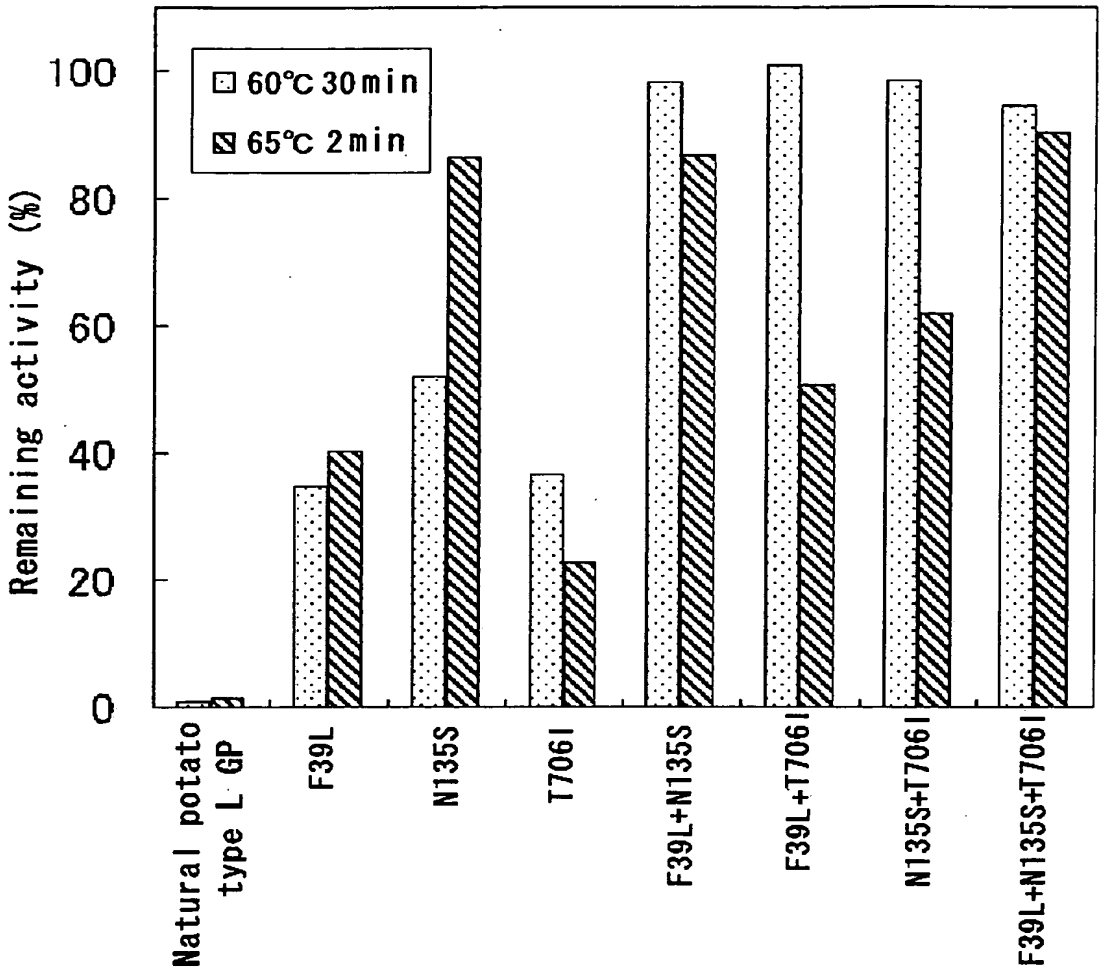

Remaining activity (%)
100
80
60
40
20
0
60℃ 30min
65℃ 2min
Natural potato type L GP
F39L
N135S
T706I
F39L+N135S
F39L+T706I
N135S+T706I
F39L+N135S+T706I

Fig. 3

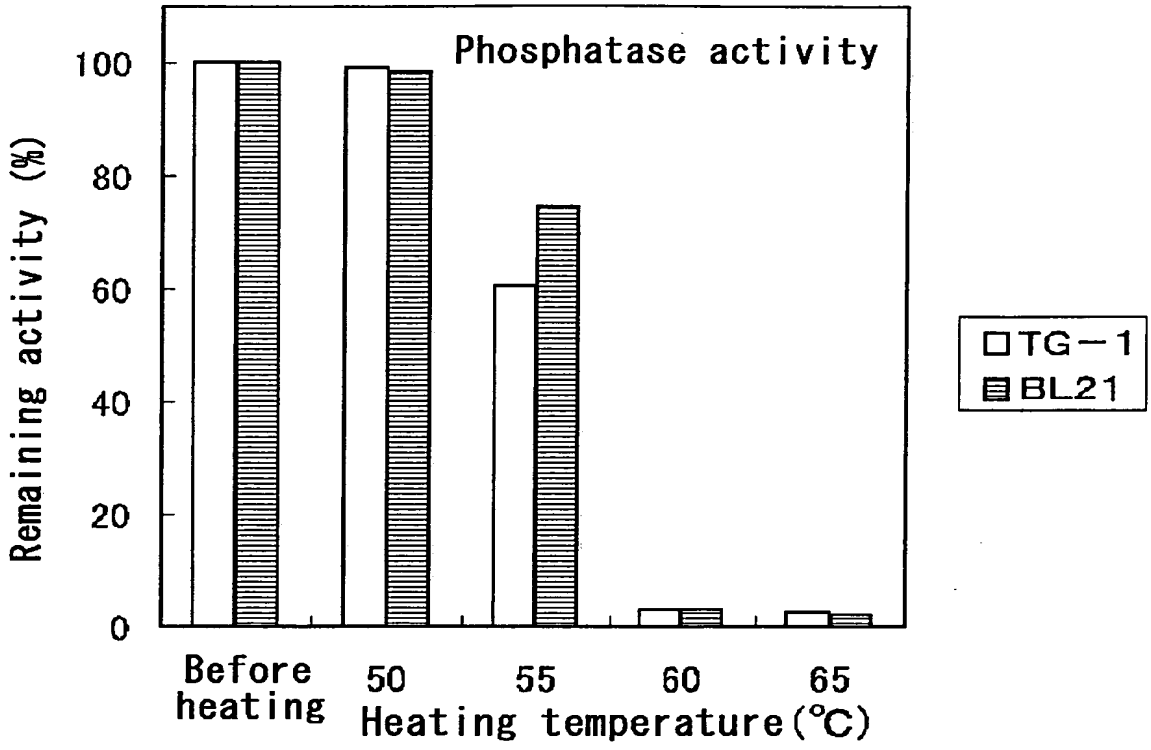

Phosphatase activity
Remaining activity (%)
100
80
60
40
20
0
Before heating
50
55
60
65
Heating temperature (℃)
TG−1
BL21

Fig. 4

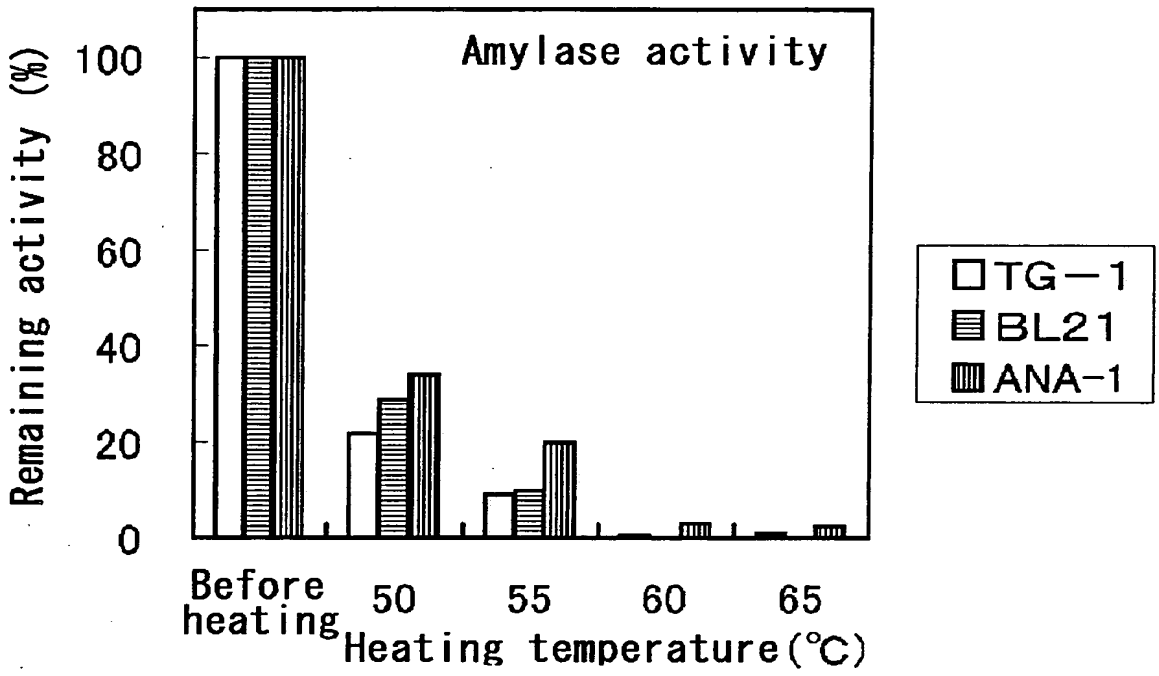

Amylase activity
Remaining activity (%)
100
80
60
40
20
0
Before heating
50
55
60
65
Heating temperature(℃)
TG−1
BL21
ANA−1

Fig. 5

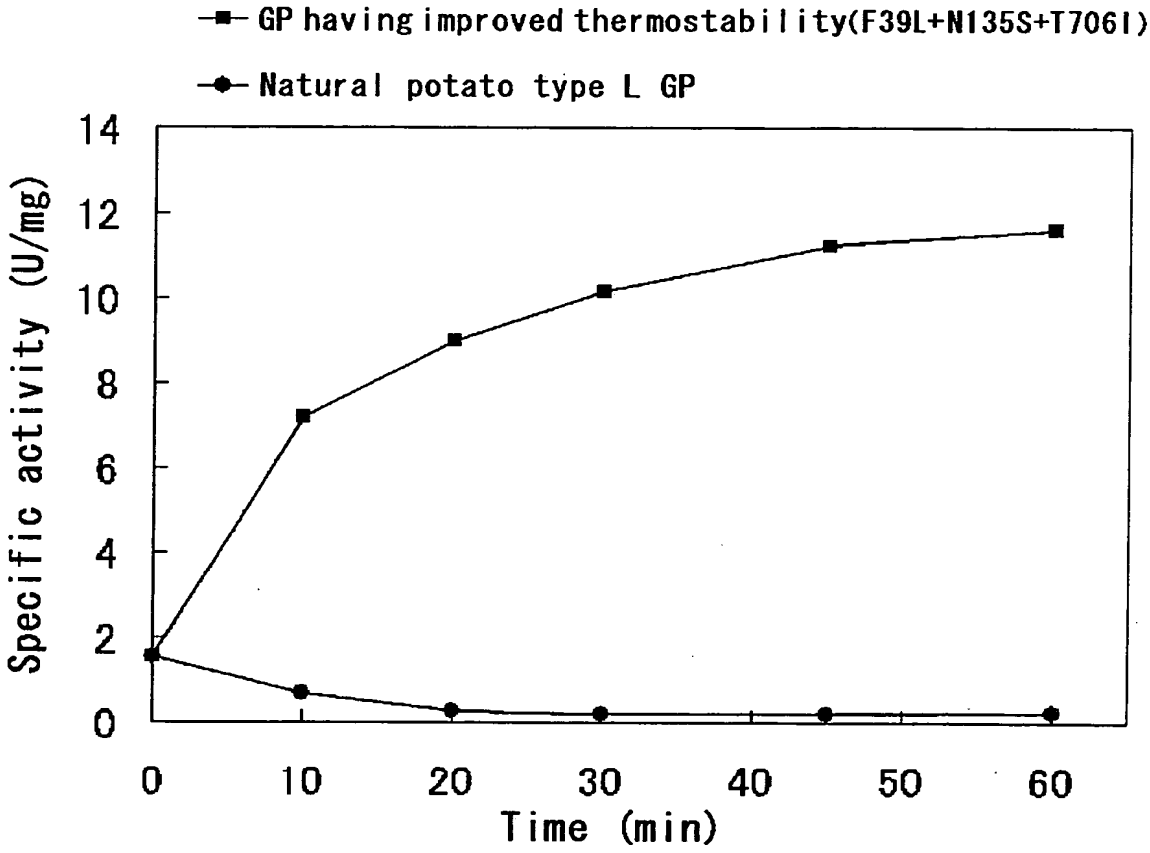

GP having improved thermostability(F39L+N135S+T706I)
Natural potato type L GP
Specific activity (U/mg)
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
Time (min)

Fig. 6

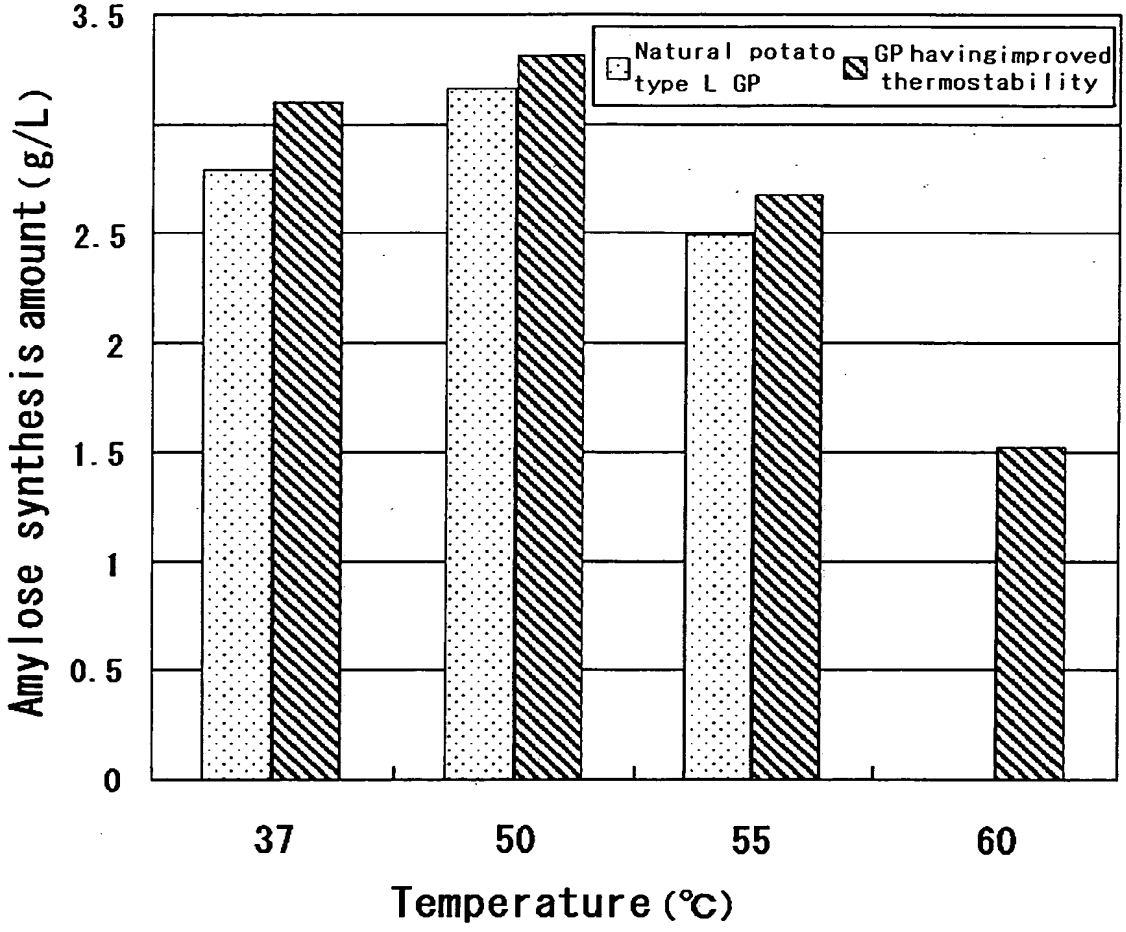

3.5
2.5
2
1.5
1
0.5
0
Amylose synthesis amount (g/L)
Natural potato type L GP
GP having improved thermostability
37
50
55
60
Temperature (℃)

Fig.7

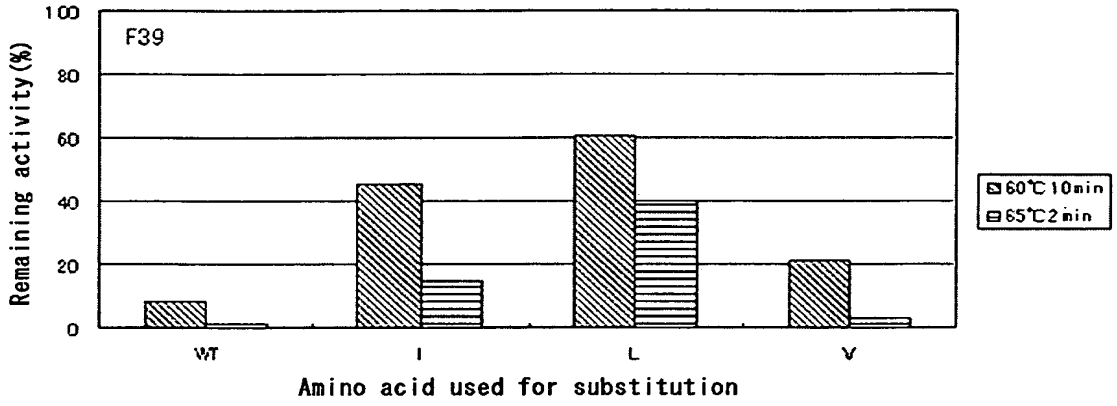

F39
Remaining activity(%)
100
80
60
40
20
0
WT
I
L
V
Amino acid used for substitution
60℃10min
65℃2min

Fig. 8

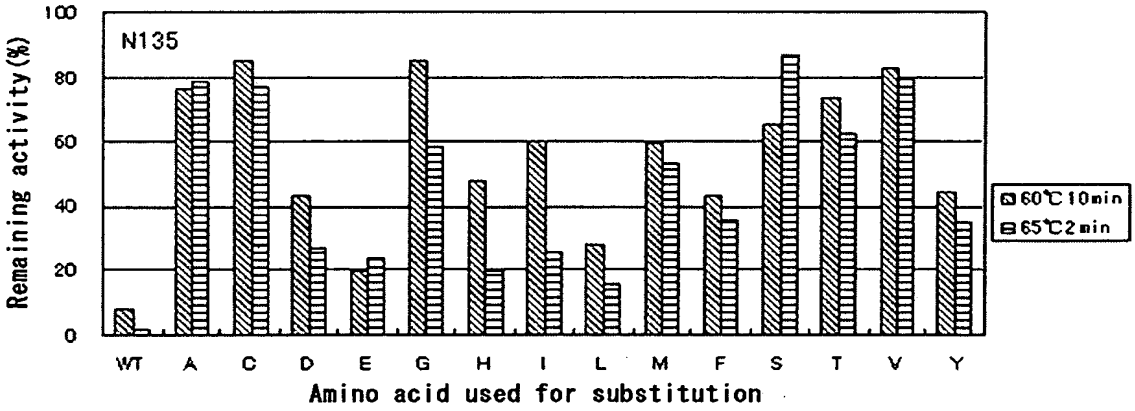

N135
Remaining activity(%)
100
80
60
40
20
0
WT A C D E G H I L M F S T V Y
Amino acid used for substitution
60℃10min
65℃2min

Fig. 9

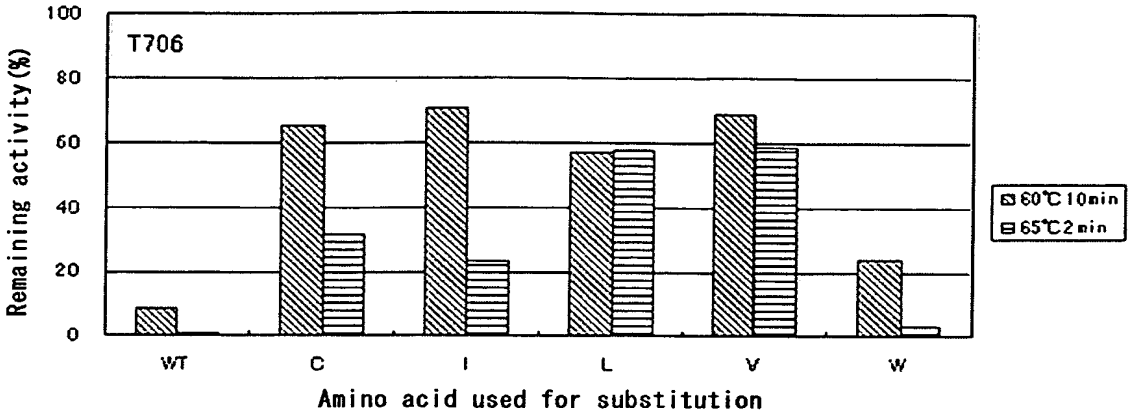
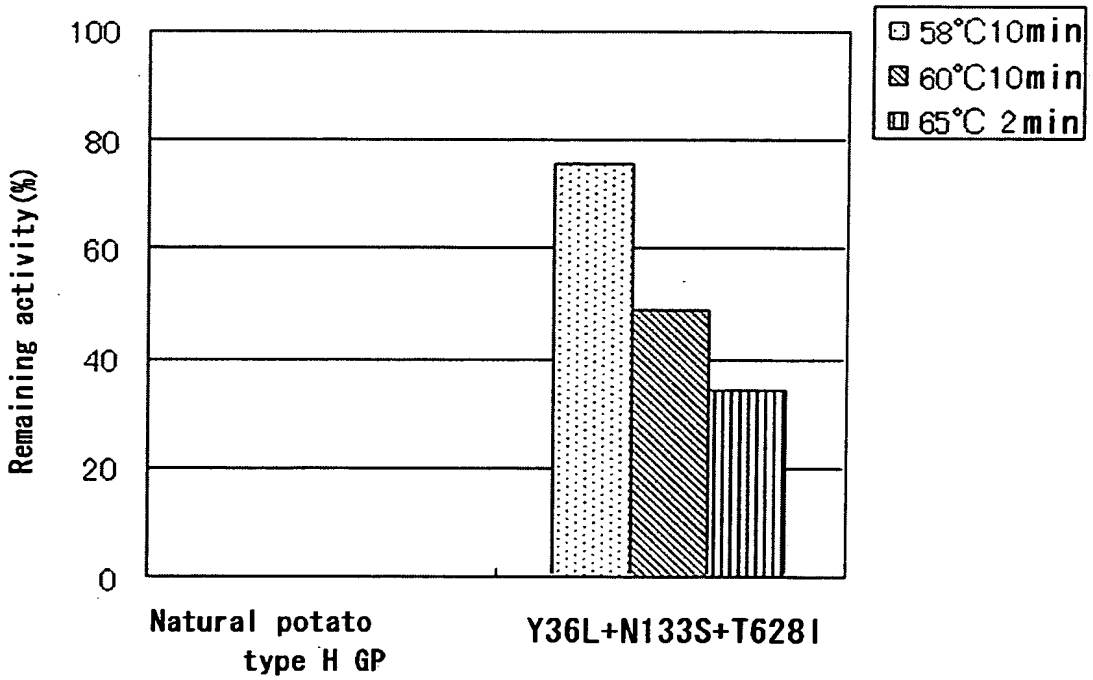


Fig. 10



Remaining activity of Potato type H GP (%)

Fig. 11

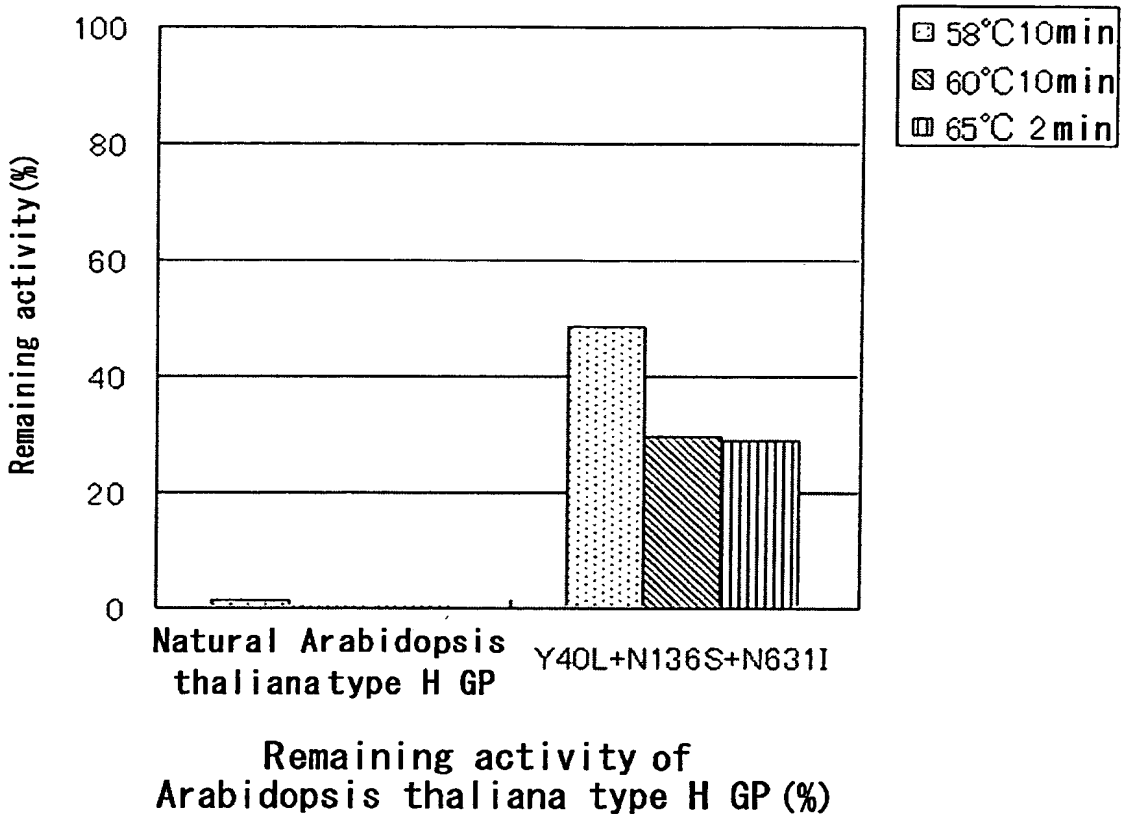
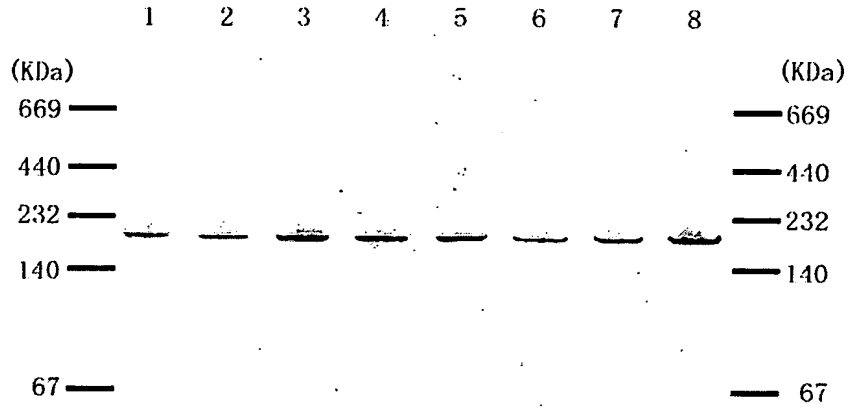
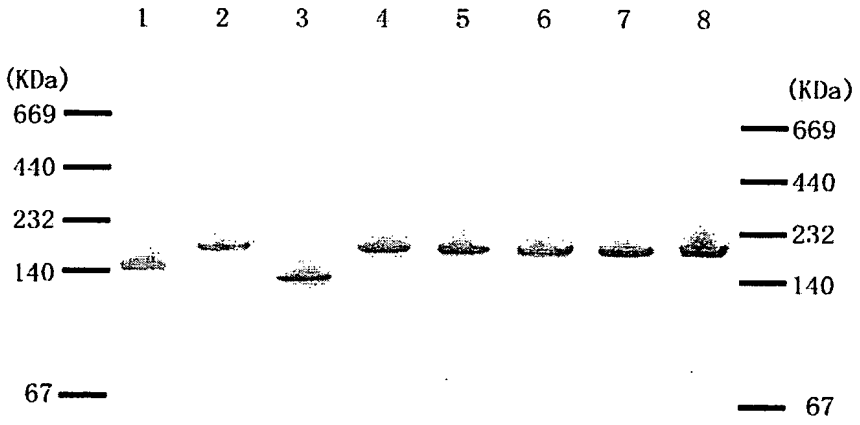

100
80
60
40
20
0
Remaining activity(%)
58°C10min
60°C10min
65°C 2min
Natural Arabidopsis thaliana type H GP
Y40L+N136S+N631I
Remaining activity of Arabidopsis thaliana type H GP (%)

Fig. 12

<Immediately after purification>



<4℃5 months>



1 : Wild type 2 : F39L 3 : N135S 4 : T706I 5 : F39L+N135S
6 : F39L+T706I 7 : N135S+T706I 8 : F39L+N135S+T706I

Fig. 13